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RESPONSES TO HARMONIC ACCELERATION WITH VARYING HEAD POSITIONS.(U)

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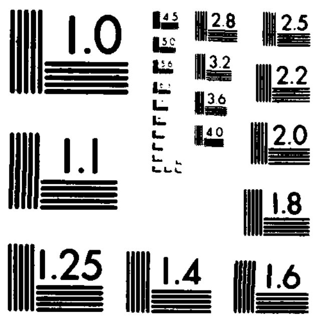

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Report SAM-TR- 82-5

RESPONSES TO HARMONIC ACCELERATION WITH VARYING HEAD POSITIONS

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Approved for public release; distribution unlimited.

USAF SCHOOL OF AEROSPACE MEDICINE
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NOTICES

This final report was submitted by personnel of the Vestibular Function, Otolaryngology Branch, Clinical Sciences Division, and the Data Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7755-17-41.

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The voluntary informed consent of the subjects used in this research was obtained in accordance with AFR 169-3.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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To determine if a particular head position results in maximal response to stimulation, 50 subjects were tested with sinusoidal acceleration in three head positions with reference to the horizontal plane. A PDP-11/34 digital computer was used to analyze the responses. The pertinent parameters were gain, phase, and directional preponderance. The results showed no difference in the parameters for the three head positions. This suggests that positioning a subject's head for rotational testing is not as critical as previously believed.

RESPONSES TO HARMONIC ACCELERATION WITH VARYING HEAD POSITIONS

INTRODUCTION

The major function of the vestibular system is to provide a stable platform for vision by initiating compensatory eye movements in response to head movements. The reflexive, compensatory eye movements--the vestibulo-oculomotor reflex (VOR)--function to keep an object in the visual field whenever the head is rotated, elevated, or tilted.

Classically, vestibular function has been tested using caloric stimulation. Within the last decade, however, advances in torque motor drive systems and minicomputers have led to increased use of rotational stimulation in clinical evaluations. We have used sinusoidal acceleration in this laboratory for several years to study the effects of peripheral and central pathology on the VOR (1-5) and the effects of surgical procedures used in treatment of vestibular disorders (6, 7) and to compare results of caloric and rotational testing (3, 8). In these studies, we assumed that maximum responses to rotational stimulation would occur when the subject's head was positioned with the chin down approximately 25°, the position where the canals are approximately in the plane of rotation. To the best of our knowledge, however, there is no experimental evidence which proves that this position produces maximum responses. This study was designed to determine if any head position consistently produces maximal responses to horizontal sinusoidal stimulation.

In 1938 Travis (9) studied the effects of various head positions on the subjective sensation of rotation. He used sinusoidal rotation and had his subjects indicate the intensity of their perception of motion when their heads were in three different positions: 0°, +45°, and -45°, with respect to the plane of the horizontal canals. His subjects reported greater sensation when their heads were in the +45° position. He postulated that this occurred because the vertical canals were being stimulated along with the horizontal canals in the 45° position. We chose head positions of 0° and ±15° on the assumption that if a subject's head is improperly positioned for testing, the error is probably within just a few degrees of the 0° position. Angles of ±15° provide sufficient range to include any error that would probably occur in clinical testing.

METHODS

From on-base volunteers, we selected 50 subjects who reported a history free of vestibular problems. Each subject was instrumented with silver silver-chloride surface electrodes in the usual manner for recording eye movements and was seated in a chair mounted on a torque motor (Contraves-Goerz, Pittsburgh, Pa., Model DP-300) inside a lightproof room. Ten minutes were allowed for dark adaptation. The test procedure consisted of three trials of .04-Hz harmonic stimulation with a 5-minute break between each trial. A technician established the desired head position before each trial and adjusted a bite bar and headrest

so that the subject could maintain the position during rotation. Subject alertness was maintained by a tone-discrimination task. A Digital Equipment Company PDP-11/34 minicomputer provided the .04-Hz driving signal and analyzed the resulting eye-movement recordings. Each trial lasted approximately 4 minutes, with a peak velocity of $60^{\circ}/s$. The technician repositioned the subject's head for the next trial during the 5-minute breaks.

A program implemented on the PDP-11/34 computer digitized the eye-movement data and calculated eye velocity and eye acceleration (10). The fast-phase components of the tracings were identified using velocity and acceleration thresholds. Once identified, the fast-phase components were removed from the eye-velocity record by linear interpolation, resulting in a record containing only slow-phase eye velocity. Frequency domain analysis was performed on the stimulus signal and the slow-phase eye-response record, producing estimates of VOR gain, phase, and directional preponderance for each trial.

Gain is defined as the ratio of the magnitude of the slow-phase eye-velocity response to the magnitude of the head-velocity stimulus. Normally, gain is in the 0.4 to 0.6 range at the frequency used in this study. Phase describes the time relationship between the stimulus and the response, and directional preponderance indicates the left-right symmetry of the response. One study (11) indicates that gain is modulated by cortical function; however, by controlling subject alertness, we minimized all but the head velocity as factors affecting gain. Phase and directional preponderance are largely independent of VOR gain.

In this study the stimulus intensity (angular velocity of the head) was held constant, but the position of the horizontal canals with respect to the plane of rotation was varied. In this manner the canals received a varying degree of stimulation. The decrement in stimulus intensity received by the canals in the $\pm 15^{\circ}$ positions can be expressed in terms of the cosine function of the angle formed by the plane of rotation and the plane of the canals. Since the cosine of 15° is 0.96, we anticipated a 4% decrease in gain when the head was in the $\pm 15^{\circ}$ position.

RESULTS

The subjects had a mean age of 32 years, ranging from 19-55 years. Of the 50 subjects, 44 (88%) were males, 27 (54%) were nonflying military, 19 (38%) were aircrew members, 4 (8%) were civilians.

Analysis of variance showed no significant differences in gain, phase, or directional preponderance for the three head positions ($p > .05$). This was true even though phase lag and preponderance did increase in the $+15^{\circ}$ position. The variability of each parameter (gain, phase, and preponderance) was similar for the three head positions. Figure 1 shows these data. Our expectation that gain would be 4% higher in the 0° position was not supported by the following: 15 subjects (30%) had higher gain values in the 0° position, 16 (32%) had higher gain values in the -15° position, and 19 (38%) had higher gain values in the $+15^{\circ}$ position.

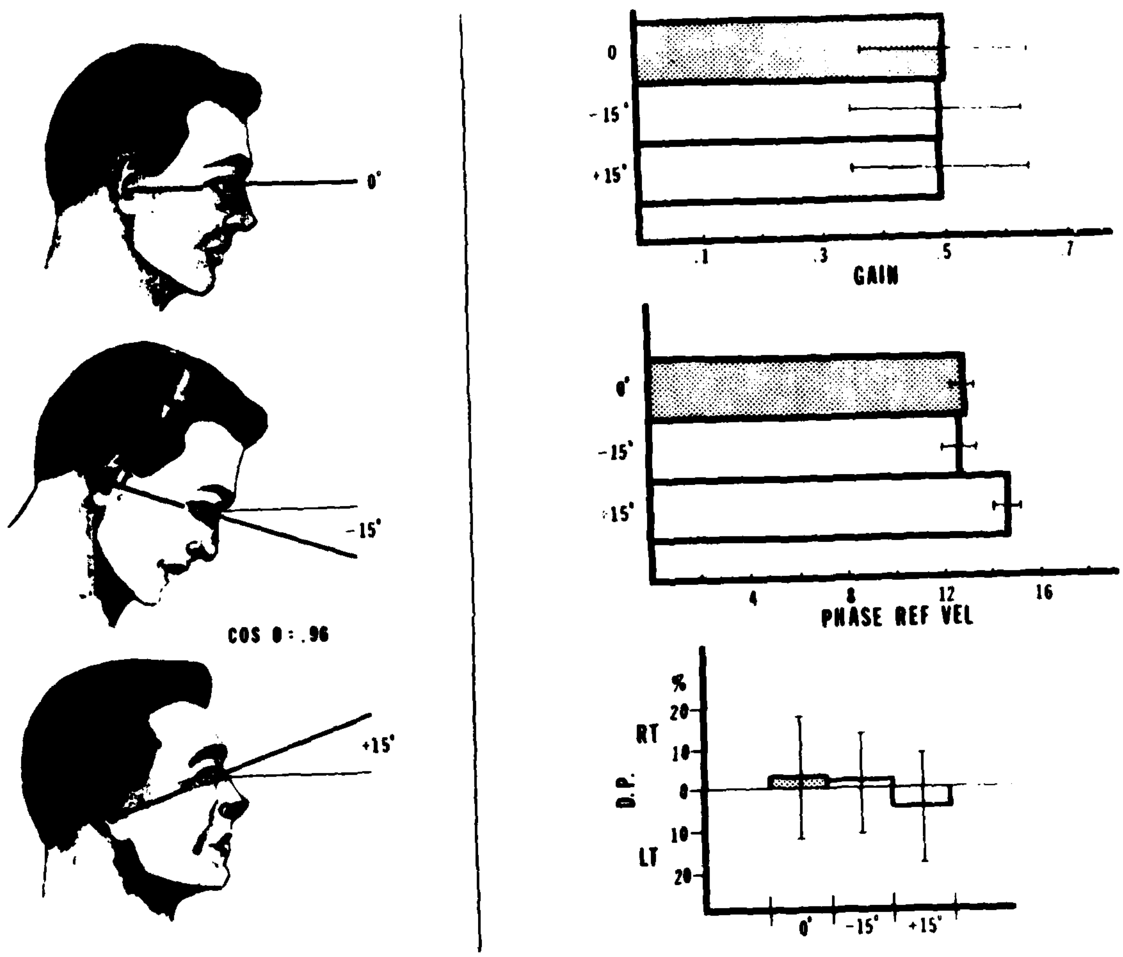

Figure 1. Head positions tested, with results for gain, phase, and preponderance.

DISCUSSION

Data from this study show that head position for rotational testing is not as critical as previously believed. Although technicians must attempt to align the horizontal canals with the plane of rotation, there is some allowance for a small margin of error and individual physiological differences. Recent anatomical studies (12, 13) have shown that the three canals on each side of the head are not exactly at right angles to each other. Also, the data from these studies confirm that the horizontal canal is tilted upward 25^{o} (instead of the commonly accepted 30^{o}) and that the medial side of the canal is higher than the lateral side. Often the planes of the two horizontal canals will differ by several degrees. Thus, positioning the head for rotational testing is a compromise: while one horizontal canal is in the plane of rotation, the other may be as much as 9^{o} out of the plane (12). Because of this, responses to rotation must be accepted as a pattern of multicanal stimulation (13). We believe that our data reflect the influence of these individual anatomical variations.

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